

# Multiplexing

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Concept

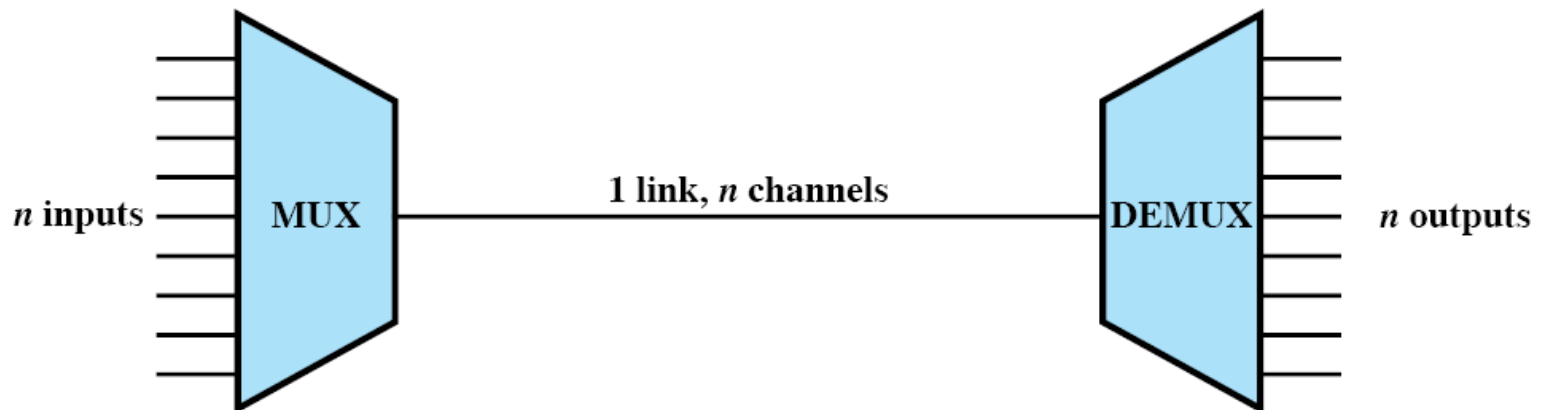
Concept

Technology



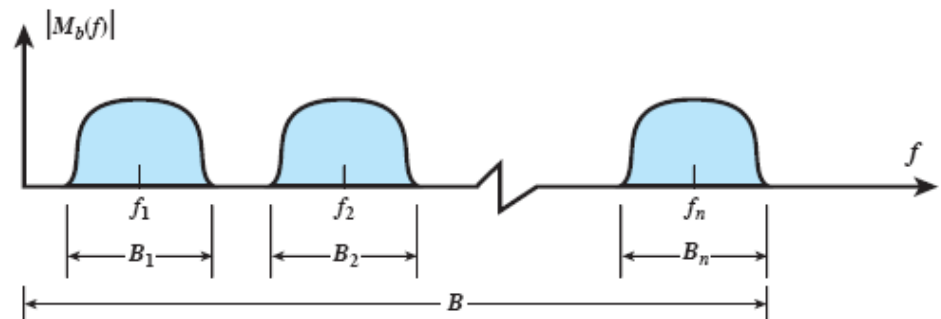
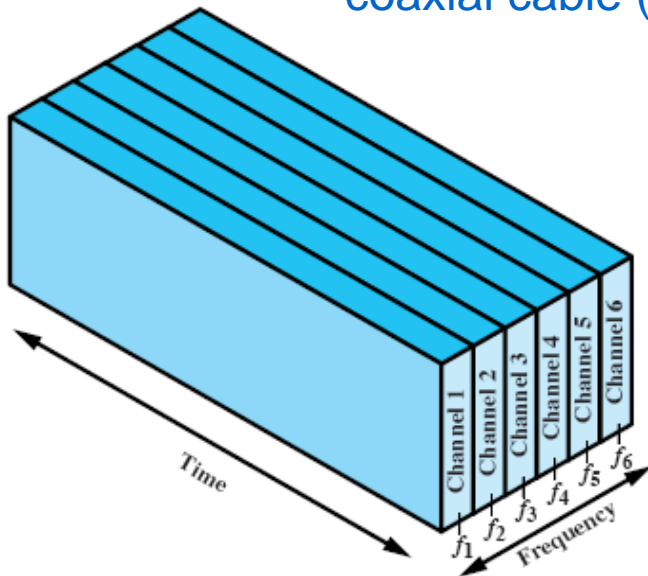
# Multiplexing

- Allow multiple stations to share the capacity of one link
- Common on long-haul, high capacity, links
- Motivation:
  - The higher the data rate, the more cost-effective the transmission system is
  - Most individual communicating devices require small to modest data rate
    - Terminals, PCs: 10's to 100's kb/s
- Alternatives:
  - Frequency Division Multiplexing (FDM)
  - Time Division Multiplexing (TDM)
  - Statistical Time Division Multiplexing (STDM)



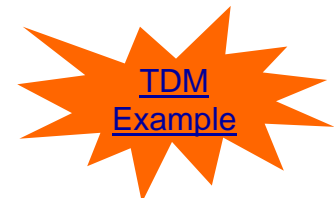
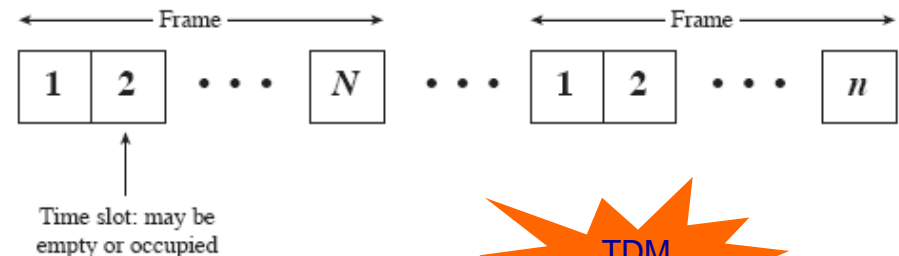
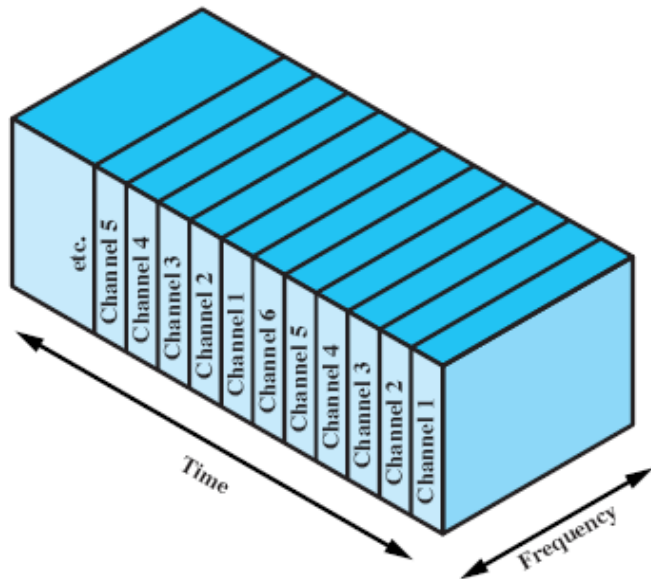
# Frequency Division Multiplexing

- FDM used when medium bandwidth is more than required bandwidth of individual signals
  - Multiple signals sent at once, providing they use different carrier or centre frequencies, and are sufficiently spaced apart
    - If not separated sufficiently, then signals will interfere with each other (errors at receiver)
  - Each signal on a carrier frequency is called a channel
  - Example: many TV signals of 6MHz can be carried on a 500MHz coaxial cable (that is, cable TV)



# Synchronous Time Division Multiplexing

- Carry multiple signals on transmission system by interleaving each signal in time
  - Interleaving either at bit level or blocks (bytes)
  - Output data rate must be greater than the sum of the input data rates at transmitter
  - *Synchronous* TDM since slots are pre-assigned to sources and fixed

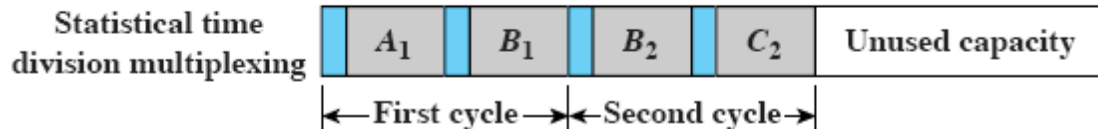
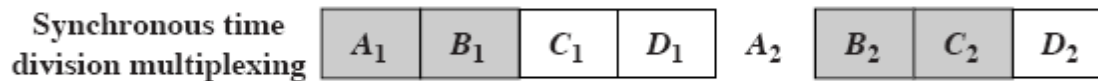
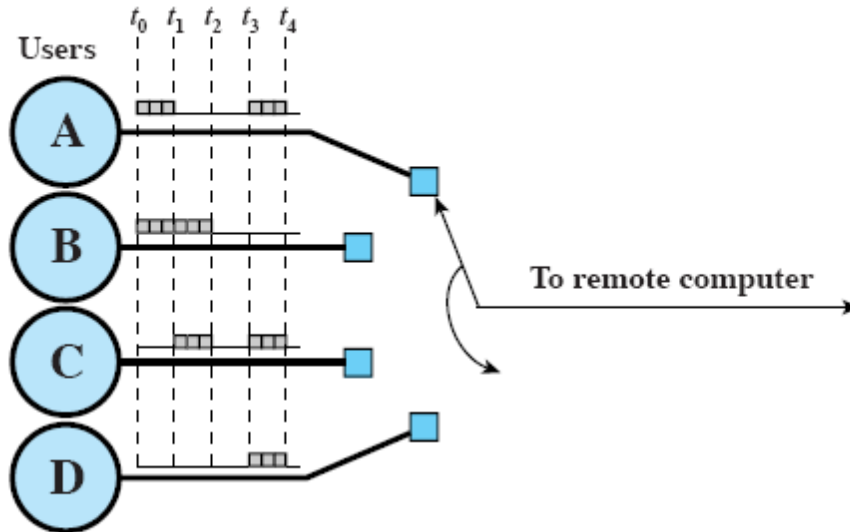


# Statistical TDM




- In Synchronous TDM, many slots are wasted
  - If a source has no data, or not the full number of sources, then an empty slot is “sent”
- Asynchronous or Statistical TDM allocates time slots dynamically based on demand
  - If a source has no data, than the multiplexer can send data from another source
  - Multiplexer scans input lines and collects data until frame full
  - Line data rate lower than aggregate input line rates
    - Assumes that the average input data is lower than line data rate
    - However, may have problems in peak periods (that is, when all inputs produce peak data)
      - Must buffer inputs, causing possible delays and dropped data

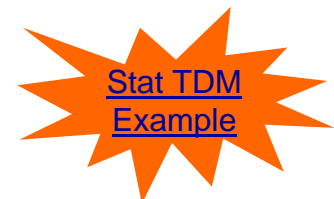


# Synchronous vs Statistical TDM



## LEGEND

-  Data
-  Address
-  Unused capacity



# Example Technologies

- FDM

- Analog telephone networks were built using FDM based on 4KHz voice channels
  - A “group” line can carry 12 voice calls
  - A “supergroup” line can carry 5 groups, and so on
- Television distribution
- ADSL combines voice and data onto a telephone line
  - Asynchronous Digital Subscriber Line

Name	Mb/s
E1	2
E2	8
E3	34
E4	140

- Synchronous TDM

- Digital networks for telephony and data use TDM
  - Plesionchronous Digital Hierarchy (PDH)
    - International System (E) and US system (T)
    - Older networks over copper
  - Synchronous Digital Hierarchy (SDH or SONET)
    - Current networks between cities and within cities, using optical fibre

Name	Mb/s
E1	2
E2	8
E3	34
E4	140

Name	Mb/s
STM-1	155
STM-4	620
STM-16	2500
STM-64	10000

- Statistical TDM

- Asynchronous Transfer Mode (ATM)
  - Used to connect networks with ISP and large organisation, e.g. within city, country
  - Can be used with SDH; typical speeds of 155Mb/s and 620Mb/s

